

# **FANET Protocol**

## **V1.1**

(November 2018)

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# 1 Introduction

This document describes the FANET protocol between all FANET nodes. FANET is an ad-hoc network in a license free frequency band.

FANET is an open source protocol. The implementation of the FANET protocol must be accurate. Otherwise FANET nodes may not work properly or the network will be disturbed.

## 1.1 Forward mechanism

A FANET data package can be forwarded by every node. To prevent too much data traffic, only one hop is allowed. If a node forwards a data package, the forward bit has to be disabled at retransmitting.

A node should retransmit the data package only, if the destination address is cached in the own address list.

**CAUTION:** Do not set the forward bit for a broadcast data package if more than 4 other nodes are in reach.

A FANET ground stations may forward the data package to other FANET ground stations, although the forward bit is not set. The FANET ground stations have to be connected through another network like the internet.

## 1.2 ACK mechanism

If the ACK (acknowledge) bit is set, the destination address should send an ACK (Type 1) back to the source address. The ACK package itself may not request an ACK.

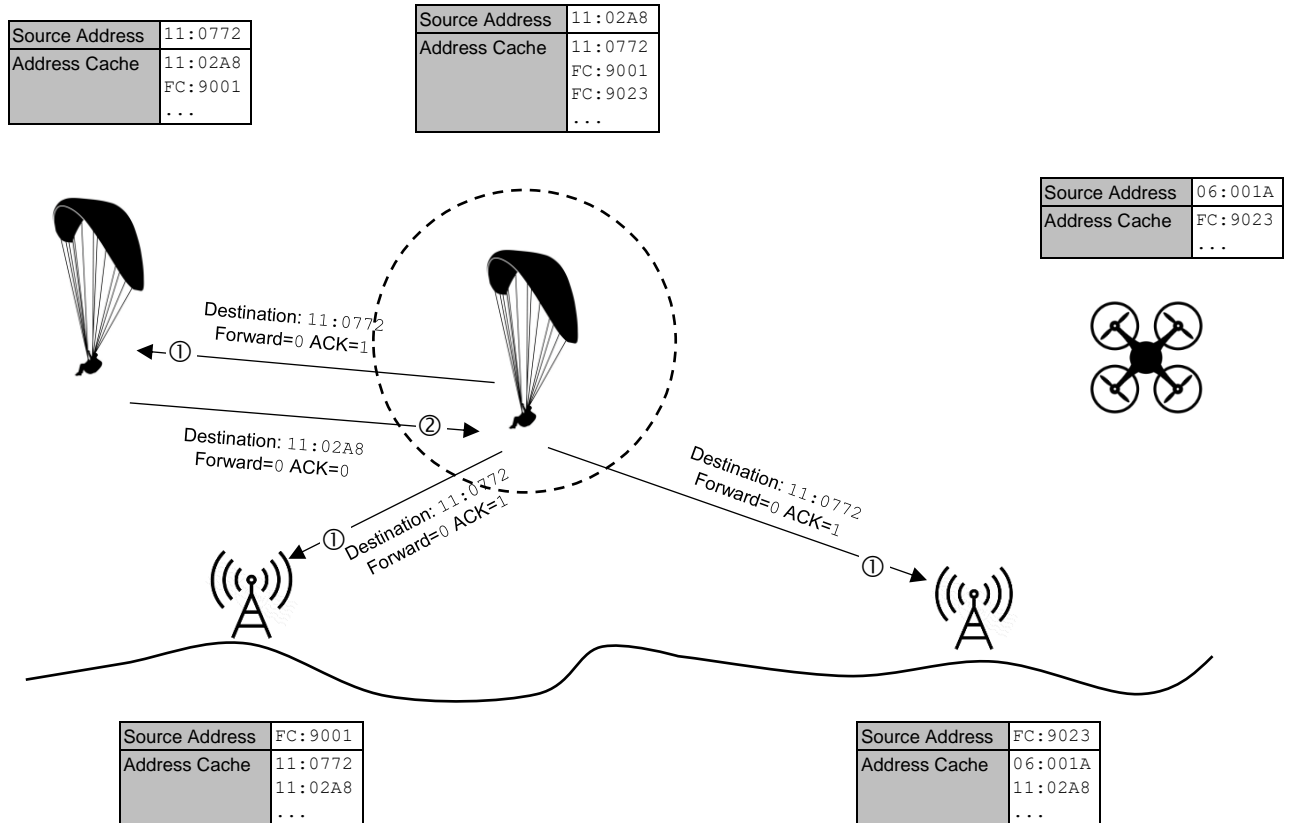
If the data package with ACK request will be forwarded, the ACK code 2 should send from the retransmitted node.

**CAUTION:** Do not set the ACK bit for a broadcast data package if more than 4 other nodes are in reach.

## 1.3 Forward and ACK examples

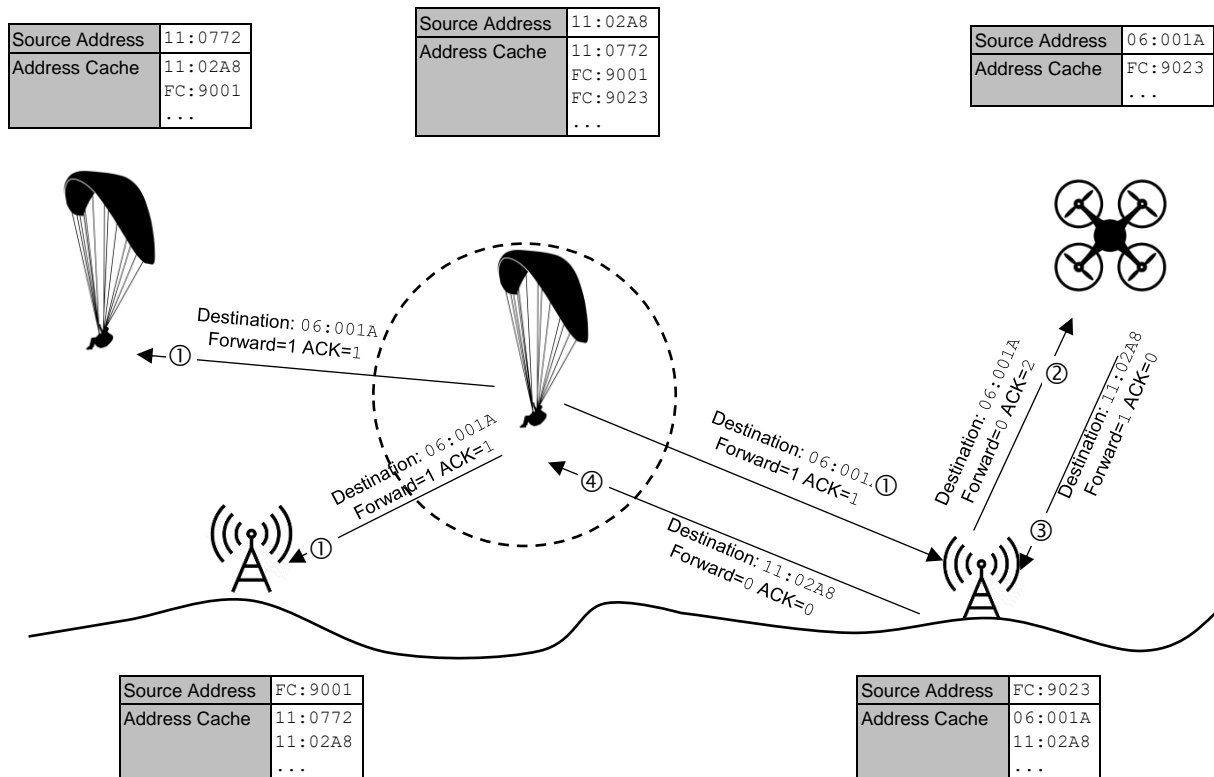
### 1.3.1 Address cached

If the destination address is cached in the source, the forward bit should not be set.



### 1.3.2 Address not cached

If the destination address is not cached in the source, the forward bit may be set.



## 2 Physical Layer

### 2.1 LoRa Configuration

FANET uses the LoRa specification. This allows long rang transmission with less energy.

Please make sure, the radio specifications are in line with the local law.

Description	Value	Comments
Frequency	868.200 MHz	EU regulation RIR1008-06
RF power	max. +14 dBm e.r.p.	EU regulation RIR1008-06
TX Duty Cycle	max. 1%	EU regulation RIR1008-06
LoRa Syncword	0xF1	
Bandwidth	250 kHz	
Spreading Factor	SF7	
Explicit Header	Yes	
Coding Rate	4/8	Reduce CR at heavy traffic
CRC for payload	Yes	

## 3 FANET MAC

### 3.1 Header

The FANET header is the first byte and specified the following data package.

Byte	Bit							
	7	6	5	4	3	2	1	0
0	E.-Header	Forward	Type					

#### E.-Header

- 0 No Extended Header follows
- 1 Extended Header follows

#### Forward

- 0 Do not Forward the data package
- 1 Forward the data package

#### Type

- 0 ACK (Acknowledge) No Payload, must be unicast
- 1 Tracking
- 2 Name
- 3 Message
- 4 Service
- 5 Landmarks
- 6 Remote Configuration
- 7 Ground Tracking

## 3.2 Source Address

The source address shows the unique device ID. The device ID is a combination of Manufacturer ID and Unique ID.

For unregistered Devices/Manufacturers: Set the Manufacturer to 0xFC or 0xFD and choose a random ID between 0x0001 and 0xFFFE. List on the channel if the ID is already used.

0xFE shall be used for multicast (E.g. competition/group messaging).

The manufacturers 0x00 and 0xFF as well as the IDs 0x0000 and 0xFFFF are reserved.

Byte	Bit							
	7	6	5	4	3	2	1	0
1	Manufacturer ID							
2	Unique ID (LSB)							
3	Unique ID (MSB)							

### Manufacturer ID

0x00	[reserved]
0x01	Skytraxx
0x03	BitBroker.eu
0x04	AirWhere
0x05	Windline
0x06	Burnair.ch
0x11	Skytraxx+FLARM, FANET+
...	
0xFC	Unregistered Devices
0xFD	Unregistered Devices
0xFE	[Multicast]
0xFF	[reserved]

### Unique ID

0x0000	[reserved]
0x0001	First ID
...	
0xFFFE	Last ID
0xFFFF	[reserved]



### 3.3 Extended Header

Only if Extended Header bit is set (Byte 0, Bit 7)

Byte	Bit							
	7	6	5	4	3	2	1	0
(4)	ACK		Cast	Signature	Reserved			

#### ACK

0	None (default)	
1	Request	
2	Request	via forward, if received via forward (received forward bit = 0). must be used if forward is set
3	Reserved	

#### Cast

0	Broadcast (default)	
1	Unicast	Add destination address (+3 Byte) Package shall only be forwarded if destination address in cache and no 'better' retransmission received

#### Signature

0	No Signature	
1	Signature	Add signature (+4 Byte)

### 3.4 Destination Address

Only if Cast bit is set in Extended Header (Byte 4, Bit 5)

Byte	Bit							
	7	6	5	4	3	2	1	0
(5)	Manufacturer ID							
(6)	Unique ID (LSB)							
(7)	Unique ID (MSB)							

#### Manufacturer ID

0x00	[reserved]
0x01	Skytraxx
0x03	BitBroker.eu
0x04	AirWhere
0x05	Windline
0x06	Burnair.ch
0x11	Skytraxx+FLARM, FANET+
...	
0xFC	Unregistered Devices
0xFD	Unregistered Devices
0xFE	[Multicast]
0xFF	[reserved]

#### Unique ID

0x0000	[reserved]
0x0001	First ID
...	
0xFFFFE	Last ID
0xFFFF	[reserved]

### 3.5 Signature

Only if Signature bit is set in Extended Header (Byte 4, Bit 4)

Use SHA1 and iterate over pseudo header (first 4 byte: type + source address, where bits 6 and 7 of byte 0 are set to 0), over the payload, and over a pre-shared secret/key.

The first 4 byte of the resulting hash shall be interpreted as 32bit integer and put into the signature field (= normal order due to little endian encoding).

Byte	Bit							
	7	6	5	4	3	2	1	0
(5) / (8)	Signature (LSB)							
(6) / (9)	...							
(7) / (10)	...							
(8) / (11)	Signature (MSB)							

#### Signature

0x00000000    Signature

The first 4 byte of the SHA1 results

...

0xFFFFFFFF

### 3.6 Length of FANET MAC

The length of FANET MAC depends on several MAC settings (Extended Header Bit, Cast Bit and Signature Bit). The following overview shows all 5 possible MAC lengths for the byte stream:

E-Header Bit = 0      Cast Bit = 0      Signature Bit = 0      SPB = 4

Byte	0	1	2	3	4	5	6	7
Stream	Header	Source Address			Payload	Payload	Payload	Payload

E-Header Bit = 1      Cast Bit = 0      Signature Bit = 0      SPB = 5

Byte	0	1	2	3	4	5	6	7
Stream	Header	Source Address			E-Header	Payload	Payload	Payload

E-Header Bit = 1      Cast Bit = 1      Signature Bit = 0      SPB = 8

Byte	0	1	2	3	4	5	6	7
Stream	Header	Source Address			E-Header	Destination Address		
Byte	8	9	10	11	12	13	14	15
Stream	Payload	Payload	Payload	Payload	Payload	Payload	Payload	Payload

E-Header Bit = 1      Cast Bit = 0      Signature Bit = 1      SPB = 9

Byte	0	1	2	3	4	5	6	7
Stream	Header	Source Address			E-Header	Signature		
Byte	8	9	10	11	12	13	14	15
Stream	Signature	Payload	Payload	Payload	Payload	Payload	Payload	Payload

E-Header Bit = 1      Cast Bit = 1      Signature Bit = 1      SPB = 12

Byte	0	1	2	3	4	5	6	7
Stream	Header	Source Address			E-Header	Destination Address		
Byte	8	9	10	11	12	13	14	15
Stream	Signature				Payload	Payload	Payload	Payload

## 4 Types

### 4.1 ACK (Type = 0)

The type ACK contains no payload and will be send if the ACK bit is set in the Extended Header. The ACK message must be send always unicast.

## 4.2 Tracking (Type = 1)

Contains tracking information from a flying object.

Byte	Bit							
	7	6	5	4	3	2	1	0
SPB + 0	Position Latitude (LSB)							
SPB + 1	...							
SPB + 2	Position Latitude (MSB)							
SPB + 3	Position Longitude (LSB)							
SPB + 4	...							
SPB + 5	Position Longitude (MSB)							
SPB + 6	Tracking	Aircraft Type			A-Scaling	Altitude (LSB)		
SPB + 7	Altitude (MSB)							
SPB + 8	S-Scaling	Speed						
SPB + 9	C-Scaling	Climb						
SPB + 10	Heading							
SPB + 11	T-Scaling	Turn Rate						

### Position Latitude

0x000000 Aircraft latitude position Latitude = value\_lat/93206  
 ... Little Endian, 2-Complement Latitude = [-90° ... +90°]  
 0xFFFFFFF Resolution = ±0.00001°

### Position Longitude

0x000000 Aircraft longitude position Longitude = value\_lon/46603  
 ... Little Endian, 2-Complement Longitude = [-180° ... +180°]  
 0xFFFFFFF Resolution = ±0.00002°

### Tracking

0 Online Tracking not allowed  
 1 Online Tracking allowed

### Aircraft Type

0 Other  
 1 Paraglider  
 2 Hangglider  
 3 Balloon  
 4 Glider  
 5 Powered Aircraft  
 6 Helicopter  
 7 UAV

### A-Scaling

0 Scaling altitude with x1 Altitude range: 0 m ... 2'047 m  
 1 Scaling altitude with x4 Altitude range: >2'047 m ... 8'188 m

### Altitude

0x000 Aircraft altitude A-Scaling Bit = 0 -> 1 m / bit  
 ... A-Scaling Bit = 1 -> 4 m / bit  
 0x7FF

**S-Scaling**

0	Scaling speed with x1	Speed range: 0 km/h ... 63.5 km/h
1	Scaling speed with x5	Speed range: >63.5 km/h ... 317.5 km/h

**Speed**

0x00	Aircraft speed	S-Scaling Bit = 0 -> 0.5 km/h / bit
...		S-Scaling Bit = 1 -> 2.5 km/h / bit
0x7F		

**C-Scaling**

0	Scaling climb with x1	Climb range: -6.4 m/s ... +6.3 m/s
1	Scaling climb with x5	Climb range: -32.5 m/s ... -6.5 m/s +6.5 m/s ... 31.5 m/s

**Climb**

0x00	Aircraft climb	C-Scaling Bit = 0 -> $\pm 0.1$ m/s / bit
...	2-Complement	C-Scaling Bit = 1 -> $\pm 0.5$ m/s / bit
0x7F		

**Heading**

0x00	Aircraft heading	Heading = value_head*360/256
...		Heading = [0°...360°]
0xFF		Resolution = 1.4°

**T-Scaling (Optional)**

0	Scaling turn rate with x1	Climb range: -15.75 m/s ... +15.50 m/s
1	Scaling turn rate with x5	Climb range: -64 m/s ... -16 m/s +16 m/s ... +63 m/s

**Turn Rate (Optional)**

0x00	Aircraft Turn Rate	T-Scaling Bit = 0 -> $\pm 0.25$ deg/s / bit
...	2-Complement	T-Scaling Bit = 1 -> $\pm 1$ deg/s / bit
0x7F		

### 4.3 Name (Type = 2)

Contains the name of the source destination. The protocol allows UTF-8 coding.

Byte	Bit							
	7	6	5	4	3	2	1	0
SPB + 0	Char 0							
SPB + 1	Char 1							
...	...							
SPB + 244	Char (244)							

#### Char 0...(244)

8 Bit      Arbitrary length  
String     \0 termination not required

Standard limitation of LoRa buffers of 256 bytes and the maximum length of the FANET MAC header of 11 bytes reduces the permitted name length to 245 bytes.



## 4.4 Message (Type = 3)

Contains the message. The protocol allows UTF-8 coding.

Byte	Bit							
	7	6	5	4	3	2	1	0
SPB + 0	Subheader							
SPB + 1	Char 0							
SPB + 2	Char 1							
...	...							
SPB + 244	Char (243)							

### Subheader

0 Normal message

### Char 0...(243)

8 Bit Arbitrary length  
String \0 termination not required

Standard limitation of LoRa buffers of 256 bytes and the maximum length of the FANET MAC header of 11 bytes and the subheader of 1 byte reduces the permitted message length to 244 bytes.

## 4.5 Service (Type = 4)

Only if Extended Header bit is set (Byte 0, Bit 7)

Byte	Bit							
	7	6	5	4	3	2	1	0
SPB + 0	Gateway	Temp	Wind	Humid	Barom	TBD	TBD	E-Header
SPB + (1)	Extended Header							
SPB + (2)	Position Latitude (LSB)							
SPB + (3)	...							
SPB + (4)	Position Latitude (MSB)							
SPB + (5)	Position Longitude (LSB)							
SPB + (6)	...							
SPB + (7)	Position Longitude (MSB)							
SPB + (8)	Temperature							
SPB + (9)	Wind heading							
SPB + (10)	S-Scale	Wind speed						
SPB + (11)	G-Scale	Wind gusts						
SPB + (12)	Humidity							
SPB + (13)	Barometric (LSB)							
SPB + (14)	Barometric (MSB)							

### Gateway

0	Internet Gateway not available	
1	Internet Gateway available	No additional payload required

### Temp

0	Temperature information not available	
1	Temperature information available	Payload +1 Byte

### Wind

0	Wind information not available	
1	Wind information available	Payload +3 Byte

### Humid

0	Humidity information not available	
1	Humidity information available	Payload +1 Byte

### Barom

0	Barometric information not available	
1	Barometric information available	Payload +2 Byte

### E-Header

0	Extended header not available	
1	Extended header available	Payload +1 Byte

**Extended header**

0x00 TBD

...

0xFF

**Position Latitude**

0x000000 Service latitude position

... Little Endian, 2-Complement

0xFFFFFF

Latitude = value\_lat/93206

Latitude = [-90° ... +90°]

Resolution =  $\pm 0.00001^\circ$ **Position Longitude**

0x000000 Service longitude position

... Little Endian, 2-Complement

0xFFFFFF

Longitude = value\_lon/46603

Longitude = [-180° ... +180°]

Resolution =  $\pm 0.00002^\circ$ **Temperature**

0x00 Temperature value

... 2-Complement

0xFF

 $\pm 0.5^\circ\text{C}$  / bit

[-64°C ... +63.5°C]

**Wind heading**

0x00 Wind heading

...

0xFF

Heading = value\_head\*360/256

Heading = [0° ... 360°]

Resolution =  $1.4^\circ$ **S-Scaling**

0 Scaling wind speed with x1

1 Scaling wind speed with x5

Speed range: 0 km/h ... 25.4 km/h

Speed range: &gt;25.4 km/h ... 127 km/h

**Wind speed**

0x00 Wind speed

...

0xFF

S-Scaling Bit = 0 -&gt; 0.2 km/h / bit

S-Scaling Bit = 1 -&gt; 1 km/h / bit

**G-Scaling**

0 Scaling wind gusts with x1

1 Scaling wind gusts with x5

Speed range: 0 km/h ... 25.4 km/h

Speed range: &gt;25.4 km/h ... 127 km/h

**Wind gusts**

0x00 Wind gusts

...

0xFF

G-Scaling Bit = 0 -&gt; 0.2 km/h / bit

G-Scaling Bit = 1 -&gt; 1 km/h / bit

**Humidity**

0x00 Humidity value

...

0xFF

0.4 %rh / bit

[0 %rh ... (102) %rh]

**Barometric**

0x0000 Barometric value

... Absolut pressure

0xFFFF

0.01 hPa / bit, Offset: 430 hPa

[430 ... 1085.36 hPa]

## 4.6 Landmarks (Type = 5)

\*\*\* *Pending* \*\*\*

## 4.7 Remote Configuration (Type = 6)

Note 1: Signature (symmetric) is highly recommended

Note 2: In order to indicate a successful configuration the receiver shall transmit the configured feature instantaneously.

[Byte 0]

bit 7-0

Subtype:

- 0: Acknowledge configuration: Byte [1] subtype of ack
  - 1: Request / Advertise configurable ... TODO
  - 2: Position. Byte [1-6] latitude/longitude, Byte [7-8] altitude, Byte [9] heading (encoded like in type 1)
  - 3: Reply feature (recommended for name). Byte [1] is type (and forward bit) followed by the payload.
  - 4 .. 7: Reply feature. Byte [1] is type (and forward bit) followed by the payload.
  - 8 .. 15: Reply feature (recommended for landmark slots 0 .. 7). Byte [1] is type (and forward bit) followed by the payload.
- A feature with no further payload is considered to be removed.

## 4.8 Ground Tracking (Type = 7)

Contains tracking information from a ground object.

Byte	Bit							
	7	6	5	4	3	2	1	0
SPB + 0	Position Latitude (LSB)							
SPB + 1	...							
SPB + 2	Position Latitude (MSB)							
SPB + 3	Position Longitude (LSB)							
SPB + 4	...							
SPB + 5	Position Longitude (MSB)							
SPB + 6	Ground Type							Tracking

### Position Latitude

0x000000 Ground latitude position Latitude = value\_lat/93206  
 ... Little Endian, 2-Complement Latitude = [-90°... +90°]  
 0xFFFFF Resolution = ±0.00001°

### Position Longitude

0x000000 Ground longitude position Longitude = value\_lon/46603  
 ... Little Endian, 2-Complement Longitude = [-180°... +180°]  
 0xFFFFF Resolution = ±0.00002°

### Ground Type

0 Other  
 1 Walking  
 2 Vehicle  
 3 Bike  
 4 Boot  
 8 Need a ride  
 12 Need technical support  
 13 Need medical help  
 14 Distress call  
 15 Distress call automatically

### Tracking

0 Online Tracking not allowed  
 1 Online Tracking allowed

## 5 References

Reference	Link
FANET Flying Ad-hoh Network	<a href="https://github.com/3s1d/fanet-stm32">https://github.com/3s1d/fanet-stm32</a>
FANET Protocol	<a href="https://github.com/3s1d/fanet-stm32/blob/master/Src/fanet/radio/protocol.txt">https://github.com/3s1d/fanet-stm32/blob/master/Src/fanet/radio/protocol.txt</a>

## 6 Document history

Version	Date	Autor	Changes
0.1	2018-11-25	Bet	Initial version for consultation